UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

PC Code: 030019
DP Barcode: D425971
June 30, 2015

MEMORANDUM

SUBJECT: Ecological Risk Assessment for Section 3 New Use Expansion for 2,4-D Dimethylamine Salt Use on Grapes

TO: Deirdre Sunderland, Risk Manager Reviewer
Kathryn Montague, Product Manager Team 23
Dan Kenny, Branch Chief
Herbicide Branch
Registration Division (7505P)

FROM: Meghan Radtke, Ph.D., Biologist 6/30/15
Faruque Khan, Ph.D., Senior Scientist 6/30/15
Environmental Risk Branch I
Environmental Fate and Effects Division (7507P)

THROUGH: Sujatha Sankula, Ph.D., Branch Chief 6/30/15
Greg Orrick, RAPL (for GO) 6/30/15
Environmental Risk Branch I
Environmental Fate and Effects Division (7507P)

Albaugh, LLC has submitted a Section 3 New Use application to expand the use of 2,4-D dimethylamine salt as a foliar spray on grapes in Washington and Oregon. The proposed maximum application rate is 1.36 lb ae/A per crop cycle. Currently, the 2,4-D grape use is restricted to California at that same rate, but a risk assessment at the 1.36 lb ae/A application rate is not available. In addition, a pollinator analysis has not been performed. Consequently, the Environmental Fate and Effects Division performed a risk assessment for the expansion of grapes, but relied on information in other recent 2,4-D assessments, whenever possible.

EFED's risk assessment concludes that there are no direct risk concerns for fish, aquatic invertebrates, and aquatic plants. Direct risk concerns were identified for birds, mammals, and terrestrial plants. Direct risk concerns could not be precluded for terrestrial invertebrates because the data set is incomplete. Indirect effects were

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identified for any species that relies on birds, mammals, terrestrial plants, or terrestrial invertebrates for food, habitat, or other resources (Table 1).

Table 1. Summary of Risk Conclusions for 2,4-D Dimethylamine Salt on Grapes

Taxon	Direct Risks	Indirect Risks
Birds (surrogate for reptiles and land-phase amphibians)	Acute risks **(high certainty)** Listed - all size classes consuming short grass, tall grass, broadleaf plants and fruits/pods (small birds only) Non-listed – small and medium size classes consuming short grass, broadleaf plants, and tall grass (small birds only)	Yes
Mammals	Acute risks **(high certainty)** Listed – small and medium mammals consuming short grass, tall grass, broadleaf plants, and arthropods; large mammals consuming short grass Chronic risks **(high certainty)** Listed and non-listed – small and medium mammals consuming short grass, tall grass, broadleaf plants, and arthropods (small mammals only); large mammals consuming short grass	Yes
Terrestrial plants	Risk concerns to listed and non-listed monocots and dicots (runoff only) **(high certainty)**[1]	Yes
Terrestrial invertebrates	Risk concerns cannot be precluded for adults (chronic) and larvae (acute and chronic) because data are not available **(low certainty)**	Yes
Freshwater fish	No risk concerns **(high certainty)**	Yes
Estuarine/marine fish	No risk concerns **(high certainty)**	Yes
Freshwater invertebrates	No risk concerns **(high certainty)**	Yes
Estuarine/marine invertebrates	No risk concerns **(high certainty)**	Yes
Aquatic vascular plants	No risk concerns **(high certainty)**	Yes
Aquatic non-vascular plants	No risk concerns **(high certainty)**	Yes

[1] Spray drift is not a concern due to ground application with hooded sprayer.

Key Uncertainties and Information Gaps

Several ecological uncertainties were identified. Table 2 lists studies that could be used to address these uncertainties.

Table 2. Ecological Toxicity Data Gaps for 2,4-D Dimethylamine Salt

Guideline #	Data Gap	Justification
850.2100	Avian Oral Toxicity Test for Passerines	An acute oral dietary study with a passerine species is currently being evaluated.
Non-guideline	Acute and Chronic Toxicity to Larval Honeybees	Under the Pollinator Risk Assessment Framework (USEPA 2014a), acute and chronic data for larval honeybees are required. Larvae may be more or less sensitive to pesticides than their adult counterparts. A semi-field larval feeding study (MRID 49270401) was submitted by the 2,4-D Task Force, but the mortality rate in the control group was too high for meaningful comparisons with treatment groups to be made. Protocols were recently submitted and evaluated for these studies.
Non-guideline	Chronic Toxicity to Adult Honeybees	Under the Pollinator Risk Assessment Framework (USEPA 2014a), toxicity data are needed for chronic exposures to adult honeybees. A protocol should be submitted in advance of conducting the study.

Introduction

2,4-D dimethylamine salt is an herbicide in the phenoxy or phenoxyacetic acid family that is used preplant, preemergence and postemergence for selective control of broadleaf weeds. It is currently registered on a number of crops including: cereal grains, corn, sorghum, soybean, sugarcane, rice, pome fruit, stone fruit, tree nuts, berries, grapes, potatoes, pastures, ornamental turf, fallow land, non-cropland, forestry, and aquatic weed control. Albaugh, LLC has submitted an application to the U.S. Environmental Protection Agency (EPA) to expand the foliar spray grape use, which is limited to California only, to the states of Oregon and Washington. The maximum application rate would remain at a single application per year of 1.36 lb ae/A and be limited to ground spray equipment (hooded boom).

Although 2,4-D dimethylamine salt has already been registered for use on grapes in California, a risk assessment at the 1.36 lb ae/A application rate is not available; the RED modeled applications at 1 and 2 lb ae/A, but not 1.36 lb ae/A. In addition, a pollinator analysis has not been performed. However, when possible, this assessment will rely on other recent 2,4-D risk assessments and cite those rather than repeating information in detail.

Problem Formulation

Nature of the Chemical Stressor

2,4-D is a plant growth regulator (synthetic auxin herbicide) in the phenoxy or phenoxyacetic acid family. 2,4-D causes disruption of multiple growth processes in susceptible plants by affecting proteins in the plasma membrane, interfering with RNA production, and changing the properties and integrity of the plasma membrane. Disruption of reproductive processes may occur resulting in sterile or multiple florets and nonviable seed production. Symptoms may appear on young growth almost immediately after application, but death may not occur for several weeks.

Environmental Fate Bridging Strategy

The 2,4-D diethylamine salt form of 2,4-D is a derivative of 2,4-D acid. The environmental fate strategy for 2,4-D is based on bridging the data on the degradation of 2,4-D esters and 2,4-D salts to 2,4-D acid [Registration Standard for 2,4 Dichlorophenoxyacetic acid (2,4-D), 1988, 540/RS-88-115]. The bridging data provide information on the time of dissociation of 2,4-D amine salts and the rate of hydrolysis of 2,4-D esters and indicate that under most environmental conditions, 2,4-D amine salts will degrade rapidly to form 2,4-D acid. A detailed environmental fate data bridging strategy can be found in the 2005 Registration Eligibility Document (RED) for 2,4-D (USEPA 2005a). Table A-1 in Appendix A provides selected physico-chemical properties of 2,4-D dimethylamine salt.

Environmental Fate and Transport

The physicochemical properties suggest that 2,4-D acid is soluble in water (569 mg/L). The vapor pressure (1.4×10^{-7} mm Hg) and Henry's Law Constant (8.56×10^{-6} atm-m^3/mol) indicate that 2,4-D acid has low volatility. 2,4-D acid is unlikely to bioaccumulate in fish given the low value of the log *n*-octanol/water partition coefficient (log K_{ow} 0.18 at neutral pH).

Table A-1 in Appendix A also provides environmental fate properties of 2,4-D acid, along with the major and minor degradates detected in the submitted environmental fate and transport studies. The major routes of degradation for 2,4-D are aerobic and anaerobic biodegradation and it is stable to hydrolysis at pH 5, 7, and 9. The degradation of 2,4-D acid appears to be dependent on oxidative microbially-mediated mineralization in the terrestrial and aquatic environments and to some extent aqueous photolysis. Soil degradation half-lives range from 1.4 to 12.4 days under aerobic conditions. Only minor degradates, 2,4-dichlorophenol (2,4-DCP) and 2,4-dichloroanisol (2,4-DCA), were identified in soils. The photodegradation half-life of 2,4-D acid was 12.9 days in a pH 5.0 buffer solution and a major degradate, 1,2,4-benezenetriol (37% of applied) was identified. 2,4-D acid was stable to photodegradation in soil.

2,4-D acid was not stable in aerobic aquatic environments ($t_{1/2}$=15.0 days) but was moderately persistent to persistent ($t_{1/2}$=28.5 to 333 days) in anaerobic aquatic laboratory studies. The major degradates were chlorohydroquinone (CHQ) (maximum of 16.0 % of applied) in aerobic aquatic conditions and 2,4-DCP (maximum of 32.6 % of applied) under anaerobic aquatic environment.

The registrant conducted a total of 30 terrestrial field dissipation studies in CA, CO, NC, ND, NE, OH, and TX on bare ground plots as well as plots cropped with corn, pasture, turf, and wheat. The 2,4-D acid half-lives ranged from 1.1 to 42.5 days with a median half-life of 6.1 days. These half-lives reflect dissipation from the surface soil layer (0 to 6 inches). The data indicate a rapid to moderately rapid dissipation rate for 2,4-D acid. The results of this study are also consistent with half-lives from laboratory studies and confirm the conceptual model for 2,4-D dissipation. The physicochemical and environmental fate properties are presented in Appendix A (Table A-1).

Degradates and Impurities

There were three major degradates identified in the submitted environmental fate studies for 2,4-D; 1,2,4-benzenetriol (37% formed), 2,4-dichlorophenol (2,4-DCP) (32.6% formed), and chlorohydroquinone (CHQ) (16% formed). Minor degradates included 4-chlorophenol, 4-CPA and 2,4-DCA (Appendix A, Table A-2). The exposure of 1,2,4-benzenetriol and CHQ in the environment are likely to be low. The 1,2,4- benzenetriol degradate was eliminated from concern because it is formed only via aqueous photolysis and less likely to occur under oxidative microbial-mediated mineralization of 2,4-D. The exposure of CHQ in the environment is likely to be low since it formed in aerobic aquatic environments with a rapid degradation half-life of 5 days. Detailed rationale for not including these degradates can be found in recent ecological risk assessment (USEPA 2013; D400223). Although 2,4-DCP is a minor degradate in the terrestrial environment, it is a major degradate (<32%) under anaerobic aquatic conditions. There are some toxicity data for 2-DCP available in the ECOTOX database[1] and the European Footprint database[2] that suggest it is more toxic than 2,4-D for selected aquatic organisms. Therefore, 2,4-D as well as its degradate, 2,4-DCP, will be considered as independent stressors of concern in ecological risk assessment.

Polychloro dibenzo-*p*-dioxin (PCDD) and polychloro dibenzo-*p*-furans (PCDF) may be formed during the manufacture of 2,4-D and can remain in the products as impurities. According to 2,4-D registrants, since the 1990’s, the manufacturing processes for 2,4-D and its chemical intermediate, dichlorophenol, have been modified to reduce concentrations of PCDD and PCDF in the technical 2,4-D products. The previous assessment concluded that the environmental loading of PCDD and PCDF from terrestrial and aquatic uses of 2,4-D is not expected to pose a risk for reproductive effects to piscivorous birds and mammals (USEPA 2005b; D317729).

Exposure Assessment

Aquatic Exposure Modeling for 2,4-D Dimethylamine Salt

A Tier II screening-level surface water exposure for aquatic risk assessment was conducted for the Section 3 proposed new use registration. Modeled application rates are based on the maximum use rate of the proposed labels for use on grapes in Oregon and Washington and the CA Grape Scenario. Since the 2,4-D dimethylamine salt dissociates rapidly, the aquatic exposure was based on the 2,4-D acid equivalent.

Surface Water Concentration Calculator (SWCC) Model

The Surface Water Concentration Calculator (SWCC v 1.106) model was used to

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1 http://cfpub.epa.gov/ecotox/
2 http://sitem.herts.ac.uk/aeru/footprint/en/index.htm

generate surface water EECs for the Tier II aquatic exposure assessment. The SWCC is a graphical user interface that runs the Pesticide Root Zone Model (PRZM, v 5, November 15, 2006) and the Variable Volume Water Body Model (VVWM, 3/6/2014) (USEPA, 2006). Simulations are run for multiple (usually 30) years and the EECs represent peak values that are expected once every ten years based on the thirty years of daily values generated during the simulation. The SWCC input parameters for 2,4-D are shown in Table B-1 and resulting SWCC output in Appendix B. The peak concentration of 1.05 µg/L, 21-day concentration of 0.92 µg/L and 60-day concentration of 0.70 µg/L for surface water EECs were associated with application to grape scenario in California.

Monitoring Data

Monitoring data considered in a previous assessment (USEPA 2004) were the United States Geological Survey's (USGS) National Water Quality Assessment Program (NAWQA) groundwater and surface water database, USGS/EPA reservoir monitoring database, National Drinking Water Contaminant Occurrence Database (NCOD), and USEPA's Storage and Retrieval environmental data system (STORET). Review of these databases was conducted to provide peak and median concentrations. Additionally, the quality of data was evaluated for targeting pesticide use areas, detection limits, and analytical recoveries. The monitoring data indicate that 2,4-D is detected in groundwater and surface water. The highest time-weighted annual mean (TWAM) concentration was 1.45 µg ae/L from the NAWQA database containing non-targeted data reflecting pesticide concentrations in flowing water as opposed to more stationary bodies of water such as ponds, lakes, and reservoirs. Also, 2,4-D is detected in treated (finished) drinking water. Maximum concentrations of 2,4-D in surface source water and ambient groundwater are 58 µg ae/L and 14.8 ug ae/L, respectively.

Monitoring data from the USGS NAWQA program were accessed on June 19, 2015 to evaluate the current trend of 2,4-D concentrations in surface water and groundwater. All data of filtered surface water and groundwater were downloaded since the drinking water memorandum was issued in 2004. For surface water, a total of 2866 water samples were analyzed and 2,4-D was detected in 20.4% (i.e. 584 samples from a total national dataset of 2866 samples). The maximum concentrations of 2,4-D ranged from 0.0077 µg ae/l to 8.72 µg ae/L. For groundwater, a total of 1286 water samples were analyzed and 2,4-D was detected in 1.0% of the samples (i.e. 13 samples from a total national dataset of 1286 samples). The maximum concentrations of 2,4-D ranged from 0.0077 µg ae/L to 2.18 µg ae/L. Percent of detection and the reported concentration are lower than in the previously reported drinking water memorandum (USEPA 2004). Several mitigation measures may have contributed to the lower concentrations of 2,4-D in NAWQA surface water and groundwater monitoring in the years since the RED was issued (2005). The following mitigation measures were placed in the RED to reduce 2,4-D loading in the environment (USEPA 2005a):

- The application rate was reduced from 2.0 to 1.5 lb ae/A per year for turf uses.

- Master label rates were lower than the existing labels rates for various uses. All registrants must conform use rates to those set forth in the 2,4-D master label and reflected in the 2,4-D RED label table.

- Measures to control spray drift described in the "Spray Drift Management" section in the RED to reduce the risk of 2,4-D to non-target plants.

Terrestrial Exposure Estimates for Dimethylamine Salt

The Terrestrial Exposure (T-REX) model (Version 1.5.2) was used to estimate exposure concentrations of 2,4-D to birds (surrogate for reptiles and land-phase amphibians) and mammals. The model calculates the peak concentration of pesticide residues on each food item on a daily interval for one year using a first order decay function based on the concentration present from the initial application (note, only one application is being proposed for the grape use). In addition to exposure concentrations (dose and diet-based), the T-REX model calculates risk quotients based on food items for mammals and birds. For dose-based exposures, three weight classes of mammals (15, 35, and 1000 g) and birds (20, 100, and 1000 g) are considered. A default foliar dissipation half-life of 35 days was used in this assessment.

Exposure Estimates for Birds and Mammals

The estimated exposure concentrations of 2,4-D dimethylamine salt for birds and mammals are presented in Tables 3 and 4, respectively. These estimates are based on the upper-bound Kenaga dose and the assumption that the species in question eat one type of food item and forage only in the treated and/or overspray areas.

Table 3. Avian Exposure Concentration Estimates for a Single Foliar Application at 1.36 lb ae/A

Feeding Category	Dietary-based EECs (mg/kg-food item)	Dose-based EECs (mg/kg-bw)		
		Small (20 g)	Medium (100 g)	Large (1000 g)
Short grass	326.40	371.74	211.98	94.91
Tall grass	149.60	170.38	97.16	43.50
Broadleaf plants	183.60	209.10	119.24	53.38
Fruits/pods	20.40	23.23	13.25	5.93
Arthropods	127.84	145.60	83.03	37.17
Seeds	20.40	5.16	2.94	1.32

Table 4. Mammalian Exposure Concentration Estimates for a Single Foliar Application at 1.36 lb ae/A

Feeding Category	Dietary-based EECs (mg/kg-food item)	Dose-based EECs (mg/kg-bw)		
		Small (15 g)	Medium (35 g)	Large (1000 g)
Short grass	326.40	311.20	215.08	49.87
Tall grass	149.60	142.63	98.58	22.86
Broadleaf plants	183.60	175.05	120.98	28.05
Fruits/pods	20.40	19.45	13.44	3.12
Arthropods	127.84	121.89	84.24	19.53
Seeds	20.40	4.32	2.99	0.69

Exposure Estimates for Terrestrial Invertebrates

For terrestrial invertebrates, the acute environmental exposure concentrations (EECs) from a foliar spray of 2,4-D dimethylamine salt to adult honeybees were calculated as follows (Table 5) (USEPA 2014a):

Table 5. Honeybee EECs Based on a Single Maximum Application Rate of 1.36 lb ae/A

Exposure Route	EEC Equation	EEC
Acute Contact	(single app rate) x (2.7 µg ae/bee)	3.7 µg ae/bee
Acute Dietary	(single app rate) x (110 µg ae/g) x (0.292 g/day)	43.7 µg ae/bee

EECs were not calculated for larval honeybees or chronic exposures to adults because corresponding toxicity data are not available.

Exposure Estimates for Plants

TerrPlant 1.2.2 (10/29/09) was used to derive EECs in runoff and in spray drift, and develop risk quotients for non-listed and listed species of monocots and dicots inhabiting dry and semi-aquatic areas. For this use, the label indicates a hooded boom should be used when making applications, thus spray drift is considered negligible for the assessment. The estimated exposure concentrations of 2,4-D dimethylamine salt for terrestrial plants are presented below (Table 6).

Table 6. Terrestrial Plant Exposure Concentration Estimates for a Single Application at 1.36 lb ae/A

Description	Equation	EEC (lb ae/A)
Runoff to dry areas	(A/I)*R	0.068
Runoff to semi-aquatic areas	(A/I)*R*10	0.68
Total for dry areas	((A/I)*R)+(A*D)	0.068
Total for semi-aquatic areas	((A/I)*R*10)+(A*D)	0.68

Ecological Effects Assessment

A bridging strategy has been developed for 2,4-D toxicity data. 2,4-D toxicity is usually reported in "acid equivalents" so that toxicity data can be compared among forms. Only the most sensitive 2,4-D toxicity value from the broader 2,4-D dataset will be used in risk quotient calculations; however, given that there is a difference between the toxicity of esters and amines/salts/acid in aquatic systems, only toxicity data from the latter will be considered for aquatic exposures and terrestrial plants (runoff exposure pathway), unless it is unavailable. Ester data will be used in the absence of salt/amine/acid data. For terrestrial animal scenarios, the most sensitive 2,4-D toxicity value will be used, regardless of the chemical form (USEPA 2005a).

The ECOTOX database and European Footprint database yielded toxicological information for aquatic organisms indicating that 2,4-DCP, a major degradate of 2,4-D, is more toxic than 2,4-D. References from the Footprint database were not available for review. ECOTOX sources were not formally reviewed; however the implication of 2,4-DCP's higher toxicity is incorporated into the risk characterization section of the document.

Aquatic Effects Summary

In general, 2,4-D dimethylamine salt is slightly toxic to fish and invertebrates, and practically non-toxic to aquatic-phase amphibians, on an acute basis. There is some toxicity to aquatic plants as well. Table 7 presents the most sensitive toxicity endpoints that are being used in this risk assessment. Ester endpoints are presented only if salt/amine data are not available. For a more robust description of toxicity, see USEPA 2013 and/or 2005a.

Table 7. Toxic Effects in Aquatic Animals and Plants

Test	Species	2,4-D Form Tested	Toxicity Value (mg ae/L)	Study Classification	MRID #
Acute Freshwater Fish	Rainbow trout (*Oncorhynchus mykiss*)	2,4-D choline salt	96-h LC_{50} > 48	Acceptable	48892401
Chronic Freshwater Fish (early life cycle)	Fathead minnow (*Pimphales promelas*)	Dimethylamine salt of 2,4-D	NOAEC = 14.2* Based on length	Acceptable	41767701

Test	Species	2,4-D Form Tested	Toxicity Value (mg ae/L)	Study Classification	MRID #
Acute Estuarine/ Marine Fish	Tidewater silverside (*Menidia beryllina*)	Diethanolamine salt of 2,4-D	96-h LC_{50} > 80.24	Acceptable	42018301
Chronic Estuarine/ Marine Fish	Sheepshead minnow (*Cyprinodon variegatus*)	Butoxyethyl ester of 2,4-D	NOAEC = 0.05554* Based on survival	Acceptable	41345701
Acute Freshwater Amphibians	Leopard frog tadpoles (*Rana pipiens*)	Dimethylamine salt of 2,4-D	96-h LC_{50} = 278*	Supplemental	44517306
Acute Freshwater Invertebrates	Water flea (*Daphnia magna*)	2,4-D acid	48-h LC_{50} = 25*	Acceptable	41158301
Chronic Freshwater Invertebrates	Water flea (*Daphnia magna*)	Diethanolamine salt of 2,4-D	NOAEC = 16.05* Based on survival and reproduction	Acceptable	42018303
Acute Estuarine/ Marine Invertebrates	Eastern oyster (*Crassostrea virginica*)	Isopropylamine salt of 2,4-D	96-h EC_{50} = 49.6*	Acceptable	41429003
Chronic Estuarine/ Marine Invertebrates	Eastern oyster (*Crassostrea virginica*)	ACR**	NOAEC = 31.8* Based on ACR	ACR	ACR
Non-Vascular Aquatic Plant	Freshwater diatom (*Navicula pelliculosa*)	Dimethylamine salt of 2,4-D	EC_{50} = 3.88* Based on growth inhibition	Acceptable	41505903
Vascular Aquatic Plant	Duckweed (*Lemna gibba*)	Diethanolamine salt of 2,4-D	EC_{50} = 0.2992* NOAEC = 0.047* Based on reduction in frond number and plant number	Acceptable	42712204

*Denotes value used for calculating risk quotients

** $\frac{EC_{50(oyster)}}{NOAEC_{(oyster)}} = \frac{EC_{50\ (waterflea)}}{NOAEC_{(waterflea)}} = \frac{49.6}{X} = \frac{25}{16.05} = 31.8 = NOAEC_{(oyster)}$

Terrestrial Effects Summary

In general, 2,4-D choline salt is practically non-toxic to terrestrial insects, slightly toxic to mammals, and moderately toxic to birds, on an acute basis. Terrestrial dicots appear to be more sensitive than monocots. Table 8 presents the most sensitive toxicity data that are used for this risk assessment. For terrestrial plants, the most sensitive salt/amine are presented, whereas for terrestrial animals, the most sensitive 2,4-D endpoint, regardless of its form, is presented. For a more robust description of toxicity, see USEPA 2013 and/or 2005a.

Table 8. Toxic Effects in Terrestrial Animals and Plants

Test	Species	2,4-D Form Tested	Toxicity Value	Study Classification	MRID #
Avian Acute Oral Toxicity	Northern bobwhite quail (*Colinius virginianus*)	Triisopropanolamine salt of 2,4-D	LD_{50} = 218.7 mg ae/kg-bw* NOAEL = 67.5 mg ae/kg-bw Sub-lethal effects: lethargy, reduced reaction to external stimuli, depression, lower limb weakness, wing droop, prostrate posture, loss of righting reflex, and ruffled appearance	Acceptable	41644401
Avian Acute Dietary Toxicity	Northern bobwhite quail (*Colinius virginianus*)	Triisopropanolamine salt of 2,4-D	LC_{50} > 3035 mg ae/kg-diet NOAEL = 961 mg ae/kg-diet Sub-lethal effects: decrease in body weight gain	Acceptable	41644402
Avian Acute Dietary Toxicity	Mallard Duck (*Anas platyrhynchos*)	Triisopropanolamine salt of 2,4-D	LC_{50} > 3035 mg ae/kg-diet NOAEL = 1706 mg ae/kg-diet Sub-lethal effects: decrease in body weight gain and feed consumption	Acceptable	41644403
Avian Chronic Reproduction	Northern bobwhite quail (*Colinius virginianus*)	2,4-D acid	LOAEC > 962 mg ae/kg-diet NOAEC = 962 mg ae/kg-diet* No effects	Acceptable	45336401
Mammalian Acute Oral	Rat (*Rattus norvegicus*)	Triisopropanolamine salt of 2,4-D	LD_{50} = 441 mg ae/kg-bw*	Acceptable	41413501
Mammalian Chronic Toxicity	Rat (*Rattus norvegicus*)	2,4-D acid	NOAEL = 55 mg ae/kg-bw Based on rat developmental study and reproduction data that indicate a threshold	Acceptable	00130407 47417902 47417901

Test	Species	2,4-D Form Tested	Toxicity Value	Study Classification	MRID #
			where 2,4-D accumulation in the body outpaces elimination (see USEPA 2014b, D418022 for a detailed discussion)		
Acute Terrestrial Invertebrate Contact Toxicity	Honeybee (*Apis mellifera*)	2-ethylhexyl ester of 2,4-D	LD_{50} > 66 µg ae/bee Sub-lethal effects: lethargy and loss of equilibrium	Acceptable	44517301
Acute Terrestrial Invertebrate Oral Toxicity	Honeybee (*Apis mellifera*)	2,4-D choline salt	LD_{50} > 62.6 µg ae/bee Sub-lethal effects: reduced coordination	Acceptable	48892404
Terrestrial Plant Seedling emergence	<u>Monocot</u> Sorghum (*Sorghum bicolor*)	2,4-D dimethylamine salt	EC_{25} = 0.026 lb ae/A NOAEC = 0.015 lb ae/A (based on fresh weight)	Acceptable	42389501
	<u>Dicot</u> Lettuce (*Lactuca sativa*)	2,4-D dimethylamine salt	EC_{25} = 0.026 lb ae/A NOAEC = 0.020 lb ae/A (based on dry weight)	Acceptable	47106001
Terrestrial Plant Vegetative Vigor	<u>Monocot</u> Onion (*Allium cepa*)	2,4-D acid	EC_{25} ≥ 0.0075 lb ae/A NOAEC < 0.0075 lb ae/A (based on fresh weight)	Acceptable	42416801
	<u>Dicot</u> Lettuce (*Lactuca sativa*)	2,4-D dimethylamine salt	EC_{25} = 0.0038 lb ae/A NOAEC = 0.0017 lb ae/A (based on dry weight)	Acceptable	47106002
*Denotes value used for risk quotient calculation					

Incident Database Review

The Environmental Protection Agency maintains an incident database system called the Ecological Incident Information System (EIIS) to track and evaluate accidental kills associated with pesticide use. The 2,4-D Problem Formulation contains a comprehensive list of all incidents reported in the EIIS as of August 6, 2012 (USEPA 2012). The database contained approximately 460 plant incidents, 22 fish incidents, 2 non-specified aquatic incidents, 4 mammal incidents, 4 bird incidents, and 1 honeybee incident. Given that 2,4-D is an herbicide, it is not surprising that the vast number of reported incidents are related to plants. Many of these were lawn/turf grass incidents where browning or mortality occurred as a result of the application (some applications were considered "misuse," but many were registered uses). In agricultural settings, direct treatment and spray drift were commonly cited as the cause of damage. Overall, the diversity and number of reported plant incidents supports the premise that 2,4-D has the potential to affect non-target plants.

Many of the other incidents (fish, aquatics, bird, mammals, honeybee) involved other chemicals in addition to 2,4-D. The presence of more than one pesticide, especially if 2,4-D is not explicitly tested for and detected, increases the uncertainty of the cause of the incident. Below is a list of the non-plant incidents that were most likely caused by 2,4-D (Table 9). These incidents demonstrate that registered uses of 2,4-D may have adverse effects on non-target fish and birds.

Table 9. Selected Non-Plant Ecological Incidents Associated with 2,4-D from the EIIS Database

	Incident Number (Source)	Taxa	Magnitude	Year	State	Use	Legality of Use	Certainty Category	2,4-D Residues	Other Chemicals Involved	Comments
2,4-D	I000636-017	Catfish	Several	1987	MO	Home/ lawn	Registered	High probability	N/R	No	Mortality caused by runoff into a pond
2,4-D	I000799-003	Turkey Cardinal Blackbird Duck Bream Bass	Duck, Bream, Bass – hundreds All others – Unknown	1991	NC	Home/lawn	Not determined	Probable	2,4-D tested for in duck and blackbird tissue; 2,4-D detected in water – 1 ppb	Dicamba Mecoprop Carbaryl Diazinon Pentachlorophenol Oxamyl	Mortality caused by ingestion (birds) and runoff into stream (fish)
2,4-D	B0000-300-37	Drum Bream Croaker	100 fish each	1984	SC	N/R	Not determined	Probable	N/R	No	Mortality caused by ingestion
2,4-D	I000925-001	Unknown fish	23000	1993	WV	Right-of-way, rail	Registered	High probability	Confirmed in water, concentration not reported	Triclopyr	Mortality caused by drift into stream

Risk Characterization

The risk quotient (RQ) method was used to determine if 2,4-D dimethylamine salt has the potential to cause adverse effects to non-target organisms. In the risk quotient method, the estimated environmental concentrations (EECs) are divided by acute and chronic toxicity values. The resulting unit-less risk quotients are compared to the Agency's levels of concern to determine the need for regulatory action.

Summary of Aquatic Risk Quotients

Risk Quotients for Fish, Amphibians, and Invertebrates

Risk quotients were calculated for freshwater amphibians (acute), fish (chronic), and invertebrates (acute and chronic). None of the RQs exceeded the listed species LOC of 0.05. Only non-definitive data were available for acute effects on fish. In lieu of RQs, the LC_{50}s for freshwater and estuarine/marine fish were compared directly with the peak EEC of 1.05 µg ae/L. In both cases, the LC_{50}s were much larger than the peak EEC, indicating risk concerns are unlikely (Table 10).

2,4-DCP, a major degradate of 2,4-D, may be more toxic to fish and invertebrates than 2,4-D. (USEPA 2013; D400223) considered aquatic exposure at a 2,4-D application rate of 3 apps at 1 lb ae/A, with a 12-day re-treatment interval. This scenario is expected to yield higher EECs than a single application of 1.36 lb ae/A to vineyards. No risk concerns were identified in USEPA 2013 from 2,4-DCP, consequently, none are expected for the proposed grape use.

Incident data suggest registered uses of 2,4-D result in mortality and toxic effects in freshwater fish. However, the application rate may have been higher than those of the proposed grape use. Given that the risk quotients, which were modeled with the highest application rates for grapes, were far below the LOCs, it is not expected that aquatic animals will be at direct risk from the proposed new use. However, indirect risk concerns are possible for any species that relies on a directly affected species for food, habitat, or other resources.

Table 10. Risk Quotients and Non-Definitive Data Comparisons for Aquatic Animals Using the California Grape Scenario

Taxon	Acute	Chronic
Freshwater fish LC_{50} > 48000 µg ae/L NOAEC = 14200 µg ae/L	The LC_{50} of > 48000 µg ae/L is at least 4 orders of magnitude higher than the peak EEC of 1.05 µg ae/L	<0.001
Freshwater amphibians LC_{50} = 278000 µg ae/L	<0.001	No data available
Estuarine/marine fish NOAEC = 55.4 µg ae/L	The LC_{50} of 80240 µg ae/L is at least 4 orders of magnitude higher than the peak EEC of 1.05 µg ae/L	0.013
Freshwater invertebrates EC_{50} = 25000 µg ae/L NOAEC = 16050 µg ae/L	<0.001	<0.001

Taxon	Acute	Chronic
Estuarine/marine invertebrates EC_{50} = 49600 µg ae/L NOAEC = 31800 µg ae/L	<0.001	<0.001

Risk Quotients for Aquatic Plants

Aquatic vascular and non-vascular plants yielded risk quotients below the LOC of 1 for 2,4-D. Risks from 2,4-DCP were dismissed as a preliminary scan of the open literature indicates it is less toxic to vascular and non-vascular plants than 2,4-D. Based on the risk quotient analysis, direct risks to aquatic plants are not expected (Table 11). However, indirect risk concerns are possible for any species that relies on a directly affected species for food, habitat, or other resources.

Table 11. Risk Quotients for Aquatic Plants

Taxon	Listed Species	Non-Listed Species
Vascular EC_{50} 299.2 µg ae/L NOAEC = 47 µg ae/L	0.022	<0.001
Non-vascular EC_{50} = 3880 µg ae/L	Not applicable	<0.001

Birds and Mammals

Potential acute risk concerns were identified for listed and non-listed birds (surrogate for reptiles and land-phase amphibians). Acute risk quotients ranged from < 0.01 to 2.36 and exceeded the listed species LOC of 0.1 for all size classes of birds consuming short grass, tall grass, broadleaf plants, arthropods, and fruits/pods (small birds only). The acute non-listed bird LOC (0.5) was exceeded for small and medium-sized birds consuming short grass, broadleaf plants, and tall grass (small birds only). The chronic risk quotients ranged from 0.02 to 0.34 and did not exceed the chronic LOC of 1 (Table 12). Indirect risk concerns are also possible for any species that relies on a directly affected species for food, habitat, or other resources.

Table 12. Summary of Avian Acute and Chronic Risk Quotients (RQs) for 2,4-D Dimethylamine Salt for Foliar Application to Grape

Feeding Category	Chronic (dietary-based) RQs	Acute (dose-based) RQs		
		Small (20 g)	Medium (100 g)	Large (1000 g)
Short grass	0.34	**2.36****	**1.06****	**0.33***
Tall grass	0.16	**1.08****	**0.48***	**0.15***
Broadleaf plants	0.19	**1.33****	**0.59****	**0.19***
Fruits/pods	0.02	**0.15***	0.07	0.02
Arthropods	0.13	**0.92***	**0.41***	**0.13***
Seeds	0.02	0.03	0.01	< 0.01
*Exceeds listed species LOC of 0.1 **Exceeds non-listed species LOC of 0.5				

Potential acute and chronic risk concerns were identified for mammals. The acute risk quotients ranged from <0.01 to 0.23 and exceeded the listed species LOC (0.1) for small and medium-sized mammals consuming short grass, tall grass, broadleaf plants, and arthropods. Risk concerns for listed large mammals consuming short grass were also identified. Chronic risk concerns were identified for listed and non-listed mammals (LOC = 1) for small and medium-sized mammals consuming short grass, tall grass, broadleaf plants, and arthropods (small only); large mammals consuming short grass were also a concern. Risk quotients ranged from 0.02 to 2.57 (Table 13). Indirect risk concerns also are possible for any species that relies on a directly affected species for food, habitat, or other resources.

Table 13. Summary of Mammalian Acute and Chronic Risk Quotients (RQs) for 2,4-D Dimethylamine Salt Foliar Application to Grape

Risk Quotients Based on Kenaga Upper Bound EEC	Dose-Based RQs						Chronic Dietary-Based RQs
	15 g		35 g		1000 g		
	Acute	Chronic	Acute	Chronic	Acute	Chronic	
Short grass	**0.32***	**2.57*****	**0.27***	**2.20*****	**0.15***	**1.18*****	0.30
Tall grass	**0.15***	**1.18*****	**0.13***	**1.01*****	0.07	0.54	0.14
Broadleaf plants	**0.18***	**1.45*****	**0.15***	**1.24*****	0.08	0.66	0.17
Fruits/pods	0.02	0.16	0.02	0.14	0.01	0.07	0.02
Arthropods	**0.13***	**1.01*****	**0.11***	0.86	0.06	0.46	0.12
Seeds	< 0.01	0.04	< 0.01	0.03	< 0.01	0.02	0.30
*Exceeds the acute listed species LOC of 0.1 **Exceeds the acute non-listed species LOC of 0.5 ***Exceeds chronic LOC of 1.0							

Terrestrial Invertebrates

Risk quotients could not be calculated for terrestrial invertebrates because the acute oral and contact data were non-definitive. Instead, the EECs were compared directly to the toxicity values to assess the likelihood of risk. The environmental exposure concentration (foliar spray) for honeybee via contact exposure is 3.7 µg ae/bee. When compared with the LD_{50} > 66 µg ae/bee, the estimated exposure concentration is much lower than the LD_{50} threshold. For the dietary pathway, the estimated exposure concentration for adult honeybees is 43.7 µg ae/bee/day. When compared with the LD_{50} of > 62.6 µg ae/bee, the estimated exposure concentration is about 70% of the LD_{50}, if taken at face value, which could indicate a risk concern. The LD_{50} also could be much larger, but this is an uncertainty given the "greater than" value derived from the honeybee acute oral toxicity study. The acute oral and contact analyses suggest that direct risk concerns for terrestrial invertebrates are low or unlikely.

Applications to grapes may occur when weeds are in the bud to early bloom stage; consequently, there is a potentially complete exposure pathway if honeybees are visiting blooming weeds during this time. Morton and Moffett (1972) studied the ovicidal and larvicidal effects of 2,4-D on honeybees and found that phenoxy herbicides, when fed at concentrations of 10 ppm, caused no adverse effect on brood development, but reduced amount of brood when fed at concentrations of 100 ppm. The eggs did not hatch in colonies fed the higher levels of phenoxy herbicides. These data suggest a potential for adverse effects in the hive that are either mediated by toxicity to young or by reduced care and feeding by adults. While the doses may not be the same between levels tested and levels anticipated in the 2,4-D choline use, there is a potentially complete exposure pathway and data are needed to fully assess the potential risk from 2,4-D on honeybees, solitary bees, and other terrestrial invertebrates. Given that chronic data for adult honeybees and larval data are not available, direct risk concerns to terrestrial invertebrates cannot be precluded. Additionally, indirect risk concerns are possible for any species that relies on a directly affected species for food, habitat, or other resources.

Terrestrial Plants

Risk quotients exceeded the LOC (1) for listed and non-listed terrestrial plants. Risk quotients ranged from 2.62 to 45.33 for monocots and 2.62 to 34.00 for dicots. Risk was only attributed to runoff from treated fields, because of the hooded boom application method (Table 14). The ~460 plant incidents in the EIIS database support the premise that there are direct risk concerns for terrestrial plants. Indirect risk concerns may also be possible for any species that relies on a directly affected species for food, habitat, or other resources.

Table 14. Summary of Risk Quotients for Terrestrial Plants Exposed to 2,4-D Dimethylamine Salt through Runoff

Plant Type	Listed Status	Dry	Semi-Aquatic
Monocot	non-listed	**2.62*** **	**26.15*** **
Monocot	listed	**4.53*** **	**45.33*** **
Dicot	non-listed	**2.62*** **	**26.15*** **
Dicot	listed	**3.40*** **	**34.00*** **
***Exceeds LOC of 1.			

Some forms of 2,4-D have been known to volatilize and settle on non-target plants away from the field at levels that cause damage. Ester forms of 2,4-D are more volatile than salt or amine forms, such as the 2,4-D dimethylamine salt considered in this risk assessment. Given that vapor flux data are not available for 2,4-D dimethylamine salt in vineyards as well as the North Pacific region, a quantitative analysis could not be performed at this time. There is uncertainty regarding the magnitude of risk from volatilization from 2,4-D dimethylamine salt applied to grapes.

Risk Summary

Overall, the proposed expansion of 2,4-D dimethylamine salt use on grapes into Oregon and Washington presents risk concerns for mammals (acute and chronic), birds (acute), and terrestrial plants. There is a high degree of certainty associated with these conclusions because RQs exceed the LOC for multiple size classes and food items for birds and mammals. For terrestrial plants, RQs exceed the LOC for all scenarios and there are hundreds of plant incidents documenting adverse effects from 2,4-D use. Direct risk concerns may also be possible for terrestrial invertebrates, but there is less certainty regarding this conclusion because it is based on an incomplete data set. The available acute oral and contact data for adult honeybees indicates that 2,4-D is not a risk concern for terrestrial invertebrates. However, chronic adult and acute/chronic larval data are not available, leaving gaps in the risk picture. No direct effects were identified for any aquatic taxa (fish, aquatic invertebrates, aquatic plants); however, indirect effects are possible for any species that relies on birds, mammals, terrestrial plants, or terrestrial invertebrates for food, shelter, or other resources.

Data Gaps and Uncertainties

Avian Acute Oral Toxicity Test for Passerines (850.2100): Data are required for one passerine species when a chemical is intended for outdoor use. The data have been submitted, but are still undergoing review. The current method of calculating a weight-adjusted LD_{50} using bobwhite quail or mallard duck data may over- or under-estimate risks to passerines because these birds may metabolize the chemical differently.

Estuarine/Marine Invertebrate Chronic Toxicity Test (850.1350): No acceptable data are available for the chronic toxicity of 2,4-D to marine/estuarine invertebrates. In lieu of data, the assessment estimated a chronic value based on an acute-to-chronic ratio using freshwater invertebrate data. The 2,4-D Problem Formulation identifies this as a gap, but concludes that chronic effects are unlikely, given the degradation rate of 2,4-D acid in water (USEPA 2012, D402410). The acute-to-chronic ratio method was considered valid and protective in lieu of actual data.

Acute and Chronic Toxicity to Larval Honeybees (OECD 237 and/or Non-Guideline): Acute and chronic data for larval honeybees are required for all pesticides, as outlined in the Pollinator Risk Assessment Framework (USEPA 2014a). Larvae may be more or less sensitive to a pesticide than their adult life-stage counterparts. In the absence of data, risks for larval terrestrial invertebrates were assumed.

Chronic Toxicity to Adult Honeybees (Non-Guideline): Chronic data for adult honeybees are required for all pesticides, as outlined in the Pollinator Risk Assessment Framework (USEPA 2014a). Additional data are needed to fully assess the potential risk from 2,4-D on honeybees, solitary bees, and other terrestrial invertebrates. In the absence of data, risks were assumed for terrestrial invertebrates because there is a potentially complete exposure pathway.

References

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USEPA. 2004. Revised 2,4-D Drinking Water Assessment for the Health Effects Division (HED) Reregistration Eligibility Decision Document. (DP 286666).

USEPA. 2005a. Reregistration eligibility decision for 2,4-D. Office of Prevention, Pesticides, and Toxic Substances, (7508C) EPA 738-R-05-002. June 2005.

USEPA. 2005b. Revised screening level ecological risk assessment of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) contaminants from technical products of 2,4-dichlorophenoxyacetic acid (2,4-D). Confidential memo (D317729).

USEPA. 2012. EFED Registration review problem formulation for 2,4-D. Environmental Fate and Effects Division, Office of Pesticide Programs, Washington, D.C.

USEPA. 2013. EFED environmental risk assessment of proposed label for Enlist (2,4-D choline salt), new uses on soybean with DAS 68416-4 (2,4-D tolerant) and Enlist (2,4-D + glyphosate tolerant) corn and field corn. Environmental Fate and Effects Division, Office of Pesticide Programs, United States Environmental Protection Agency (D400223).

USEPA. 2014a. Guidance for assessing pesticide risk to bees. Office of Pesticide Program, United States Environmental Protection Agency; Health Canada Pesticide Management Regulatory Agency; and California Department of Pesticide Regulation.

USEPA. 2014b. Addendum to 2,4-D choline salt section 3 risk assessment: refined endangered species assessment for proposed new uses on herbicide-tolerant corn and soybean. Environmental Fate and Effects Division, Office of Pesticide Programs, United States Environmental Protection Agency.

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Appendix A

Table A-1. Selected Physical and Chemical Properties of 2,4-D Diethylamine Salt

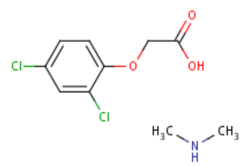
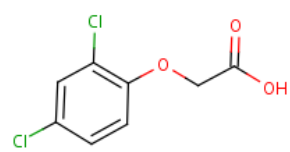
Parameter	Value	Source
Chemical structure		USEPA, 2005a
Molecular formula and weight (g/mol)	$C_{10}H_{13}Cl_2NO_3$ 266.13	
Water solubility (mg/L)	72900	
Density (g/cm^3)	1.23	
LogKow	Not applicable for end use product	
Vapor pressure (mm Hg@~25ºC)	<1 x 10^{-7}	

Table A-2. Physical Chemical and Environmental Fate Properties of 2,4-D Acid

Parameter	Value	Source
Selected Physical/Chemical Parameters		
Chemical Structure		TOXNET
IUAPC Name	(2,4-dichlorophenoxy)acetic acid	U.S. EPA, 2005a
CAS Name	(2,4-dichlorophenoxy)acetic acid	
CAS No.	94-75-7	
Molecular Weight (molecular formula)	221.04 g/mol ($C_8H_6Cl_2O_3$)	
Smiles Code	O=C(O)COc(c(cc(c1)Cl)Cl)c1	EPISUITE4.1
Vapor pressure (25°C)	1.4 x 10^{-7} mm Hg	U.S. EPA, 2005a
Aqueous solubility (20°C)	569 mg/L	
Dissociation constants (pKa) in water (25°C)	2.60	MRID 471122-02

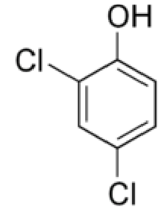
Parameter	Value	Source
Henry's Law Constant (25°C)	8.56×10^{-6} atm-m^3/mol	Rice et al, 1997
Log octanol-to-water partition coefficient (log K_{OW})	2.14 @ pH 5.0 0.18 @ pH 7.0 0.10 @ pH 9.0	U.S. EPA, 2005a
Persistence		
Hydrolysis half-life	Stable	MRID 41007301
Aqueous photolysis half-life	12.98 days Degradates[1] 1,2,4-benzenetriol (37% of applied)	MRID 41125306
Soil photolysis half-life	Stable CO_2 (5% of applied)	MRID 41125305
Aerobic soil metabolism half-life (days)	Catlin Silty clay loam – 1.7 day Commerce Loam – 4.62 days Catlin Silty clay loam – 1.4 days Fargo Clay – 12.4 days Keith Clay loam – 4.4 days Walla Walla silt loam – 2.0 days Cecil Sandy loam -2.9 days Degradates 2,4-DCP (3.5%) 2,4-DCA (2.8%)	MRID 43167501, MRID 00116625
Anaerobic aquatic metabolism half-life (total system)	333 days 28.5 days 41.0 days **Degradates** 2,4 DCP (Maximum 32.6% of applied) 4-chlorophenoxy acetic acid(4 - CPA) <2.0% of applied), 4-chlorophenol (4 - CPP) <2.0% of applied), 2,4- DCA (<2% of applied)	MRID 43356001 MRID 42979201 MRID 41557901
Aerobic aquatic metabolism half-life (total system)	15 days Inconclusive[2] **Degradates** Chlorohydroquinone (CHQ) (maximum 16% of Applied) 2,4-DCP (4.9 of applied)	MRIDs 42045301 44188601

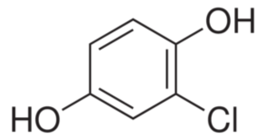
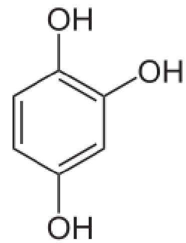
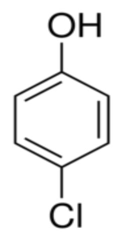
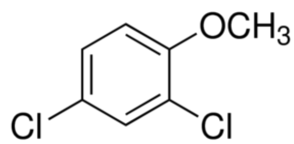
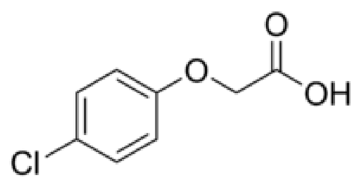
Parameter	Value	Source
	obility	
Adsorption/desorption $K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g)	Adsorption Freundlich adsorption $K_{f\text{-}ads}$ values Sand 0.36 Sandy loam 0.17 Loam 0.28 Silty clay loam 0.52 Clay 1.27 Desorption Freundlich adsorption $K_{f\text{-}des}$ values Sand 1.16 Sandy loam 0.87 Loam 1.58 Silty clay loam 1.99 Clay 1.64	MRID 44117901 MRID 42045302 MRID 44117901 MRID 42045302 MRID 44117901
$K_{foc\text{-}ads}$ / (mL/g)	Adsorption Freundlich adsorption K_{foc} values Sand 76 Sandy loam 70 Loam 117 Silty clay loam 59 Clay 58.1	MRID 42045302
Leaching	Thin Layer Chromatography (TLC) Retention Value ($R_{f,}$ unitless) (Un-aged sample) Sand 1.0 Sandy loam 0.77 Silt loam 0.60 Loam 0.41 Column Study (Aged sample) Immobile	MRID 00057313 MRID 00080124

Parameter	Value	Source
Field Dissipation		
Terrestrial field dissipation half-life	The first order half-lives ranged from 1.1 to 42.5 days with a median half-life of 6.1 days	MRID 43914701 MRID 43762401 MRID 43762402 MRID 43514601 MRID 43533401 MRID 43864001 MRID 43592801 MRID 43762403 MRID 43762404 MRID 43640601 MRID 43831702 MRID 43872703 MRID 43849102 MRID 43831701 MRID 43705202
Aquatic field dissipation half-life	Estimated dissipation half-lives of 20.7 and 2.7 days from the North Carolina pond after the first and second applications, 14 days and 6.1 days in water from a North Dakota pond after the first and second applications, and 1.0 day in water from the Louisiana rice paddy after a single application	MRID 43908302 MRID 43491601
Forest Field Dissipation half-life	The estimated half-lives for 2,4-D were 59 days in exposed soil, 68 days in protected soil, 42 days on foliage, and 72 days on leaf litter.	MRID 43954702

[1] Structures of major and minor degradates of 2,4-D are provided in Appendix Table A-3
[2]Half-life cannot be calculated because study duration was insufficient

Table A-3. Major and Minor Degradates Identified in Environmental Fate Studies

Chemical Name (CAS No.)	Molecular Formula Molecular wt.: g/mole	Chemical Structure	Maximum Formed
2,4-Dichlorophenol [2,4-DCP] (120-83-2)	$C_6H_4Cl_2O$ 163.0		32.6 % of applied in Anaerobic aquatic study

Chlorohydroquinone [CHQ] (615-67-8)	$C_6H_3(OH)_2Cl$ 144.56		16.0 % of applied in aerobic aquatic study
1,2,4-benezenetriol (533-73-3)	$C_6H_6O_3$ 126.11		37.0% formed of applied in aquatic photo-degradation study
4-chlorophenol (106-48-9)	C_6H_5ClO 128.56		<2.0% formed of applied in anaerobic aquatic metabolism study [Intermediate degradate]
2,4-dichloroanisol [2,4-DCA] (553-82-2)	$C_7H_6Cl_2O$ 177.03		<2.0% formed of applied in aerobic soil metabolism study
4-Chlorophenoxyacetic acid [4-CPA] (122-88-3)	C_8H_7ClO 186.59		<2.0% formed of applied in anaerobic aquatic metabolism study

Appendix B.

Table B-1. SWCC Input Parameter Values for 2,4-D

Parameter	Value	Source	Comments
Maximum application Rate lb a.e./A (kg a.e./HA)	Grape: 1.36 (1.52)	(EPA Reg No. 42750-19	2,4-D (46.8% a.e.)
Number of Applications	1		Early Spring
Scenario and Application Date[2]	CA Grape-13-05[1]		Surrogate scenario for OR and WA
Depth of Incorporation (inches)	0		For foliar application according to Input parameter guidance (USEPA 2009)
Method of Application	Ground spray		---
Application Efficiency	Ground: 0.99	Input parameter guidance (USEPA, 2009)	Default values for ground spray
Spray Drift Fraction	0.011	USEPA, 2014	Based on nearest droplet size and boom height specifications in the submitted labels
Molecular Mass (g/mol)	221.04	USEPA 2005	Product chemistry data
Vapor Pressure (Torr)	1.4×10^{-7}	USEPA 2005	Product chemistry data
Henry's Law Constant (atm m3/mol)	8.56×10^{-6}	Rice et al., 1997	Measured value
Solubility in Water (mg/L)	569	USEPA 2005	---
Hydrolysis $t_{1/2}$ at pH 7.0 (days)	0	MRID 41007301	Stable to hydrolysis @ pH 7.0
Aquatic Photolysis $t_{1/2}$ (days)	12.98	MRID 41125306	---

Parameter	Value	Source	Comments
Aerobic Soil Metabolism $t_{1/2}$ (d)	6.92	MRID 43167501 MRID 00116625	90th percentile upper confidence bound on the mean half-life of 2,4-D
Aerobic Aquatic Metabolism $t_{1/2}$ (d)	15 x 3[4]	MRID 420445301	Input parameter guidance (USEPA 2009)
Anaerobic Aquatic Metabolism $t_{1/2}$ (d)	321	MRID 43356001 MRID 42979201 MRID 41557901	90th percentile upper confidence bound on the mean half-life of 2,4-D
Soil Partitioning Coefficient (K_{oc}; ml/g_{oc})	76.02	MRID 44117901 MRID 42045302	Represent average K_{foc} from 5 soils
[4]= Due to reported half-life for a single aerobic aquatic metabolism study, the input half-life was multiplied by 3 according to guidance for selecting input parameters in modeling for environmental fate and transport of pesticides. Version 2.1 October 22, 2009.			

Examples of SWCC Outputs for 2,4-D

Summary of Water Modeling of 2,4-D and the USEPA Standard Pond

Estimated Environmental Concentrations for 2,4-D are presented in Table 1 for the USEPA standard pond with the CAgrapes_WirrigSTD field scenario. A graphical presentation of the year-to-year peaks is presented in Figure 1. These values were generated with the Surface Water Concentration Calculator (SWCC Version 1.106). Critical input values for the model are summarized in Tables 2 and 3.

Table 1. Estimated Environmental Concentrations (ppb) for 2,4-D .

Peak (1-in-10 yr)	1.05
4-day Avg (1-in-10 yr)	1.03
21-day Avg (1-in-10 yr)	0.923
60-day Avg (1-in-10 yr)	0.704
365-day Avg (1-in-10 yr)	0.203
Entire Simulation Mean	0.182

Table 2. Summary of Model Inputs for 2,4-D .

Scenario	CAgrapes_WirrigSTD
Cropped Area Fraction	1
Koc (ml/g)	76.02
Water Half-Life (days) @ 25 °C	45
Benthic Half-Life (days) @ 25 °C	321
Photolysis Half-Life (days) @ 40 °Lat	12.98
Hydrolysis Half-Life (days)	0
Soil Half-Life (days) @ 25 °C	6.92
Foliar Half-Life (days)	
Molecular Wt	221.04
Vapor Pressure (torr)	1.4E-07
Solubility (mg/l)	569

Table 3. Application Schedule for 2,4-D .

Date (Mon/Day)	Type	Amount (kg/ha)	Eff.	Drift
06/01	Ground	1.52	0.99	0.011

Figure 1. Yearly Peak Concentrations